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RECENT RESEARCHES

RELATING TO

NEBULÆ.

BY

PROF. A. GAUTIER.

[TRANSLATED FOR THIS JOURNAL FROM THE BIBLIOTHÈQUE UNIVERSELLE, SEPT., 1862.]

[We have translated Prof. Gautier's article, both because it furnishes a compact and clear account of the recent researches relating to nebulae, and for the sake of showing our readers the esteem in which the labors of distinguished American astronomers are held abroad. We have taken the liberty to add foot notes on one or two points where some change seemed desirable.—Eds.]

THERE is no part of the vast field of practical astronomy which does not require laborious investigation. I propose to give a general idea of those researches which relate to a very large and curious class of celestial objects first specially studied by the two illustrious astronomers Herschel and Messier, and more recently by Lord Rosse, by Fathers di Vico and Secchi,

and by Messrs. Lamont, Lassell and Bond, which present peculiar difficulties and in regard to which much remains yet to be explained. I design to speak of nebulæ, or those small white specks of feeble light which the telescope shows to exist in great numbers in the heavens, and which the most powerful instruments enable us to regard most generally as masses of stars situated at immense distances from the earth.

In this rapid review I shall follow, in general, the chronological order, commencing with a few remarks upon a catalogue of the positions of 53 nebulæ, as determined from observations made at the Observatory of Paris by M. Laugier, chiefly in the years 1848 and 1849, and presented to the *Académie des Sciences* of Paris at the session of Dec. 12, 1853. This catalogue, published in the *Compte Rendu* of that session, gives the right ascension and mean declination of the centers, or points of greatest brilliancy, of these nebulæ for Jan. 1, 1850, and also the differences between these positions and those obtained from the catalogues of Herschel and of Messier. This is the first attempt to determine the precise positions of a certain number of nebulæ, undertaken for the purpose of serving, hereafter, to decide the question whether these bodies are really situated beyond the fixed stars visible to the naked eye.

Researches upon the nebula of Orion.—M. Liapounoff, director of the Observatory of Kazan, at the beginning of 1856, presented to the Academy of Sciences of St. Petersburg, by the hand of M. W. Struve, a memoir upon the great nebula of Orion, deduced from four years' labor with an equatorial telescope, having a power equal to the telescope at Dorpat, and a meridian circle of Repsold.¹ He has undertaken to determine very exactly, by a process of triangulation, the positions of all the stars which his instruments permitted him to see in this nebula, and he has mapped with great care every part of this remarkable celestial object; several sheets are already prepared in which he has given particular names to its different regions. Comparing the results of M. Liapounoff with those previously obtained by Sir John Herschel and by Messrs. Lamont and Bond, M. Struve has expressed the opinion that this nebula must be subject to changes of form and of relative brightness in different parts.

Otto Struve has continued (at the Observatory of Pulkova) the labors of M. Liapounoff, and he has put forth the first results of his researches in a communication, dated May 1, 1857, presented to the Astronomical Society by Prof. Airy, on June 12th

¹ I have only learned of this memoir by a brief notice of it at the end of the "Monthly Notices" of the Astronomical Society of London, for March 14, 1856, vol. xvi, p. 139.

of that year, and published in the "Monthly Notices," vol. xvii, pp. 225-230.²

Struve begins by pointing out the change in the brilliancy of different small stars situated in the nebula of Orion, a variation which he has shown either by comparison of his observations with those of other astronomers, or in the progress even of his own observations.

"The existence," says Struve, "of so many variable stars in so small a space of the central part of the most curious nebula in the heavens, would naturally lead us to suppose that these phenomena are intimately connected with the mysterious nature of this body. . . . Admitting that the rapid changes of light observed in these small stars, either in the region called *Huygens* or in that called *Subnebulosa*, may be connected with the nature of the nebula, one would expect in like manner to observe changes in the appearances of the nebula and in the distribution of the nebulous matter. But observations of this kind are subject to so many illusions, that one cannot be too careful in regard to the conclusions which he draws from them. I do not believe that the view ordinarily taken by astronomers in regard to researches of this kind, to wit, the comparison of graphic representations made at different epochs by different observers, can ever lead to results which can be regarded as certain. The optical power of the telescope, the transparency of the atmosphere, (varying at different stations), the peculiarities of the eye of the observer, the degree of skill and experience in graphic representations of this sort, all this added to the influence of the imagination of the observer, form obstacles which will always be difficult to overcome in processes of this kind. It may be possible perhaps by pursuing this method for centuries to discover the existence of progressive changes, but it will never be possible to demonstrate in this manner those changes which take place in short intervals of time. But the rapid variations of light in the stars require us to give attention to similar changes, perhaps periodic, in the appearances of the nebulous matter. It is thus to rapid changes of this kind that we ought especially to direct our attention, and we shall be better able to prove their existence by comparative observations upon the degree of light and the forms of some prominent portions of the nebula, than by representing it as a whole. It is in this way that I have endeavored to proceed the past winter, and at different points I have had a strong impression that considerable changes occurred during the short period of my observations. . . . I do not allow myself, in

² I have had occasion to mention the labors of Struve in an article upon the stars of variable brightness, published in the *Bibliothèque Universelle*, for September and October, 1857, (*Archives*, tome xxxvi, p. 5 and 89). M. Otto Struve has recently succeeded his father as director of the great Russian Observatory of Pulkova.

the meanwhile, to regard these as positive facts until they have been corroborated, especially by observers located in more favorable climates and provided with optical apparatus sufficient for the purpose.”³

Struve describes in detail four parts of the nebula of Orion where he has most distinctly observed, within the interval of a few months, changes of form or of the intensity of light. The first is a bay, which extends from the strait of *Le Gentil* in the direction of a trapezium of stars situated towards the middle of the nebula. This bay appeared to him sometimes wholly obscured, like the strait, sometimes full of nebulosity, and little inferior in brilliancy to the neighboring portions of the region of *Huygens*. Dr. Lamont first mapped this bay, which had never been seen by Sir J. Herschel. The second is a *nebulous bridge* which crosses the *Sinus Magnus*, with a point of light concentrated towards its middle. Struve has seen it in winter, sometimes as Herschel and sometimes as Liapounoff represented it, with more concentration of light, but always much more extended than these two astronomers have drawn it, and very much diminishing the southern limit of the great strait. Lamont has represented it only with very feeble traces, and Bond has never seen it at all.⁴ The third is a nebulosity surrounding star 75 of Herschel's catalogue, and which appeared to Struve to be subject to great changes of brilliancy. The fourth part is a sort of *straight canal*, joining in a right line the dark space situated around the stars 76, 80 and 84 of Herschel's catalogue, with the northern border of the *Sinus Magnus* near the exterior limit of the bridge mentioned above. The canal, which had never been represented by any other observer, was distinctly seen by Struve, March 24th, 1857, although on other occasions he did not perceive the least trace of it.

This astronomer adds, in closing his communication, that the general impression produced by his observations is, that the principal parts of the central portion of the nebula of Orion are in a state of continual change of brilliancy. In those parts where the images were most distinct their appearances did not

³ The memoir of Struve upon this subject has been published, I think, in the second volume of a journal entitled, *Mélanges Mathématiques et Astronomiques*.

⁴ We must, in the interest of truth, dissent from this assertion—that the bridge over the *Sinus Magnus* “has not been seen by Bond at all.” The assertion rests on no evidence excepting its partial omission in the published engravings of Prof. W. C. Bond.

We are authorized to say that this feature may be distinctly recognized in no less than *five* original sketches made by him on as many different dates in 1847 and 1848, previous to the publication of the engraving, as well as on the very ‘copy’ from which the plate was engraved—it occurs also in several drawings made more recently.—Eds. *Am. Jour. Sci.*

seem to him to be entirely uniform on different nights. These changes in the degree of light could only be perceived, however, in a great number of cases, with instruments of considerable optical power, and he did not think they could be seen with achromatic telescopes of less than ten inches aperture, except in very favorable states of the atmosphere.

Vol. xxi of the "*Monthly Notices*" contains (pp. 203–207) an analysis of another memoir in relation to the same nebula. It was communicated to the Astronomical Society May 10, 1861, by Prof. George P. Bond, who has succeeded his father as director of the Observatory of Harvard College, at Cambridge, Mass., and it is entitled,—"*On the Spiral Structure of the Great Nebula of Orion.*"

Mr. Bond (the father) remarked, in a memoir published in 1848, that the light of this nebula had a tendency to radiate on the southerly side, separating near the trapezium from the star situated near its middle. In 1857, Mr. G. P. Bond undertook the formation of a catalogue of stars comprised within a square of 40 minutes of a degree on each side, having θ of Orion as its center. He has selected 121 brilliant stars as points by which to determine the positions of those stars which are smaller and generally have too feeble a light to be visible when the micrometer wires are strongly illuminated. He has first placed in one chart 262 stars and has divided the surface of the same into four sheets, so constructed as to be united into one. The form and arrangement of the elongated luminous clusters, alternating with spaces more or less obscure, emanating from the vicinity of the trapezium, have been determined by two independent processes, the nebula having been first sketched as a bright object upon a dark ground, and afterwards as a dark object upon a white ground.

I cannot here enter into the descriptive details given in the analysis of the memoir of Mr. Bond. I therefore confine myself to stating his conclusion that the general appearance of the greater part of the nebula of Orion is an assemblage of tufts or curvilinear pencils of luminous matter, emanating from brilliant masses adjoining the trapezium, and extending towards the south on each side of an axis passing by the summit of the region called *Huygens*, and having an angle of position of about 180° . He has distinctly traced a score of these circumvolutions, while others, producing the same impression, are too feeble or too complicated to be accurately described. It is thus possible, according to Mr. Bond, to classify the nebula of Orion among the spiral nebulæ which were first described by Lord Rosse by the aid of his great reflecting telescope. The nebula No. 51 of Messier's catalogue was the first in which this spiral arrangement, which had escaped the attention of the two Herschels, was discovered.

Mr. Bond has observed, in a great number of cases, that masses of nebulous matter are associated with stars, frequently in the form of small tufts extending from the south side. He cites two remarkable cases where there was a deficiency of luminous matter near very brilliant stars; the first was attached to the trapezium itself, the dark center of which had been noticed by many observers, and the other was attached to the star *Iota* of Orion. These peculiarities appear to Mr. Bond to favor the supposition of a physical union of the stars with the nebula. The existence of an arrangement of the parts which compose it in the form of a spiral accords with the idea of a stellar constitution: for among the objects which present this peculiarity of form are found not only nebulæ resolvable into stars but masses of stars properly so called, such for example as the great mass of stars of the constellation Hercules, where the exterior stars evidently have a curvilinear arrangement.⁵

Other facts in relation to nebulæ.—In 1860, Norman Pogson, while at the Observatory of Dr. Lee, at Hartwell, noticed a change in the nebula, or mass of stars, No. 80 of the catalogue of Messier, situated in the constellation of the Scorpion, and very near a pair of variable stars, *R* and *S* of the Scorpion, which had been studied by Chacornac since 1853. On the 9th of May this nebula had its ordinary aspect without any stellar appearance, and on the 28th of the same month Pogson saw a star of the 7th or 8th magnitude which was also observed, May 21st, at Königsberg, by Messrs. Luther and Auwers, who estimated it above the 7th magnitude. On the 10th of June following, with a magnifying power of 66, the stellar appearance had very nearly disappeared, but the nebula was much brighter than usual, with a well marked central condensation. Pogson did not think it possible to attribute this variation to a change in the nebula itself, but he regarded it as singular that a new variable star, the third comprised in the same field of view, should be found situated exactly between the earth and this nebula. This observation was published on page 32 of vol. xxi of the "*Monthly Notices.*"

Quite recently Chacornac has observed, with the great telescope of Foucault, furnished with a mirror of silvered glass, and adapted to high magnifying powers, the annular nebula of Lyra, and he has shown that it may be resolved into a mass of very small stars, exceedingly near to each other, the more brilliant occupying the extremities of the smaller diameter. This

⁵ Prof. G. P. Bond has now the means of publishing a complete account of the Observations made on the Nebula of Orion for fourteen years past with the great refractor at Cambridge, and hopes soon to set about it. The comparisons of the data can hardly fail to be interesting and to bring something new to light. Its spiral structure has been seen by Prof. Bond, in perfect distinctness, with the great Clark object-glass of 18½ inches aperture.—Eds. *Am. Jour. Sci.*

nebula, which was examined for many nights, presented to him the appearance of a hollow cylinder, seen in a direction very nearly parallel to its axis. Its centre, as Lord Rosse described it, is veiled by a curtain of nebulous matter, which is resolved into a thin stratum of small stars. Chacornac adds, in his communication upon this subject to Dr. Peters, under date of Paris, June 9th, 1862, published in No. 1368 of the "*Astronomische Nachrichten*," that when the eye is protected from all extraneous light the scintillation of this multitude of luminous points, occupying a great portion of the surface of the retina, produces a very curious vertigo.

I pass now to the labors of M. d'Arrest upon the nebulæ. This astronomer directed his attention to this subject while he was connected with the Observatory of Leipsic, and he published in 1857, in the collection of memoirs of the Royal Society of Saxony, the results of his observations upon 230 nebulæ, made with a biannular micrometer of Fraunhofer's construction applied to a telescope having an aperture of 52 lines and a focal length of 6 feet. Prof. d'Arrest is the acting director of the Observatory of Copenhagen, and has continued, since September, 1861, his observations of nebulæ, with an achromatic telescope of 11 inches aperture and a focal length of 16 feet, and with a power estimated to be intermediate between Herschel's 20 feet reflector and the telescope of the same kind with which Lassell also observed the nebulæ from 1852 to 1854. The telescope of Copenhagen has enabled d'Arrest not only to recognize all the nebulæ of Herschel, but to discover more than a hundred new ones among 776 observed in 8 months. He has also been able to see, with some difficulty, certain nebulæ described by Lassell.

D'Arrest, making his observations alone, soon perceived that he could make but little comparison of observations on celestial objects of feeble light, with the microscopic readings of the circles of his instrument. The result is that his new catalogue does not give with all possible accuracy the absolute position of each object upon the celestial sphere. The position is only given to a minute of a degree in right ascension and declination; but the nebulæ are very carefully compared with the small stars near them, by means of annular and wire-micrometers. It will thus be a good means of recognizing exactly their proper movements relative to those stars, which was the principal object of the researches of d'Arrest. This astronomer has published in No. 1366 of the "*Astronomische Nachrichten*" an interesting notice of his latest researches, dated May 20th, 1862, from which I shall extract some details tending to complete those given above.

Variation of the brilliancy of the nebulæ.—M. d'Arrest admits, upon the basis of the great work of Argelander who has made a new catalogue of stars, that among 50,000 stars already well known there is but a very small number whose light varies peri-

odically, and he thinks it is now possible, though with less certainty, to affirm that the same is true of nebulæ.

Sir W. Herschel has divided the nebulæ into three classes according to the degree of light. D'Arrest has found a great number of cases where nebulæ, such as had been first classified by Herschel, ought now to be displaced one or even two units in the classification. The latter cause has changed, in the course of a number of years, many of his own estimates of the magnitude of nebulæ. But, in view of the great diversity of atmospheric influences in moist climates, for observations of this kind, d'Arrest agrees with Otto Struve that it is not possible to be so confident in regard to conclusions deduced from variations of this kind. Meanwhile he states a small number of cases where he has been able to show some positive variation.

The first case of this kind is one deduced from observations of Struve upon the nebula of Orion which I have mentioned above. The observations upon this nebula recently made by d'Arrest, and frequently repeated, with his great telescope, on favorable nights, have confirmed those of Struve, especially those relating to the *bridge* upon the "*Sinus Magnus*," which has been frequently visible at Copenhagen the past winter, (1861-2,) and it has appeared just as it was described by Lassell.

The second case of well marked variation is the almost total disappearance of a small and feeble nebula discovered by Hind, Oct. 11th, 1852, in the constellation Taurus, recognized by other astronomers and easily discernable, at the commencement of 1856, with a telescope of 6 feet focal distance. Two years later it was seen with great difficulty in the heliometer of the observatory of Königsberg. It was invisible Oct. 3d, 1861, with the great telescope of Copenhagen. Chacornac with the new telescope of Foucault, and Lassell at Malta, with his reflecting telescope of 4 feet diameter, vainly sought it in 1862, although it has been seen with the great achromatic telescope of Pulkova.

One curious circumstance connected with the great diminution of the brightness of this nebula is that this diminution was coincident with that of a small star almost in contact with the nebula. Argelander in 1852 estimated the brightness of this star at 9.4. Its magnitude was no more than the 10th in 1858, the 11th in 1861 and only the 13th or 14th magnitude in February, 1862.

Sir John Herschel thought that he lately found another example of the disappearance of a nebula, not seeing inscribed in the first catalogue of d'Arrest a very feeble nebula described by Sir W. Herschel near two others in the Hair of Bernice. But Chacornac with the aid of the telescope of Foucault proved that this feeble nebula was still visible, and d'Arrest has also observed it with his great telescope. This astronomer mentions also a small number of cases where there may have been a variation of

brightness and even a disappearance of nebulæ, but these cases are not as well authenticated as that of Hind.

Double Nebulæ.—Sir John Herschel has remarked, in his great memoir upon nebulæ published in the *Philosophical Transactions* for 1833, p. 302, that the number of nebulæ physically connected with others is much more considerable, in proportion to the total number of nebulæ, than is the number of double stars among the fixed stars.⁶ Assuming a mutual distance of 5 minutes of a degree as the greatest distance of double nebulæ, d'Arrest has already computed about 50 comprised within this limit, and he has estimated that there may be two or three hundred in a total number of about 3000 nebulæ in that part of the heavens visible to us.⁷ This considerable proportion of double nebulæ, it is proper to presume, have a real connection in these groups, and their appearance confirmed this idea, particularly in the case where we see rare forms presented at once in two equal examples. Sir William Herschel does not appear to have had any idea of this physical connection between nebulæ, but Sir John has spoken of it clearly and frequently. There can be little doubt that it will be possible, in the distant future, to calculate the orbits of double nebulæ.

M. d'Arrest mentions some particular cases of nebulæ of this sort, one of which is triple. He recognized it only when, on comparing the distances and positions of two nebulæ, of the same group, observed in 1785, 1827 and 1862, he found sensible changes, which seemed to indicate a movement of revolution of one around the other. This particularly interesting nebula is situated in $109^{\circ} 12'$ of right ascension and $29^{\circ} 45'$ of northern declination. Lassell has represented it in No. 9 of plate XI, which accompanied his memoir, inserted in vol. xxiii of the *Transactions* (4to) of the Astronomical Society of London. The two components are very distinct although their mutual distance is actually only 28 seconds of a degree; but it is difficult to see them when the wires of the micrometer are illuminated.

A very small star is found between them, exactly at the same place where Lassell found it ten years before. M. d'Arrest will cite hereafter some other analogous cases of change in the relative positions of double nebulæ, when his work upon this subject, now in progress, is completed. He does not infer from what he has yet seen that he has found any of these groups of nebulæ with periods of revolution so short as those which have been determined for some of the double stars.

Finally d'Arrest describes a very small number of cases where

⁶ A brief analysis of these valuable researches of Sir John Herschel, accompanied with a plate, was given in the *Bibliothèque Universelle* for June and July, 1834.

⁷ M. d'Arrest has quite recently published in No. 1369 of the "*Astronomische Nachrichten*," a catalogue of the positions and appearances of 50 double nebulæ, for the beginning of 1861, which he has already recognized and of which a dozen are new.

he has been able, by comparing a nebula with some small star near it, and repeating this comparison after a certain time, to show slight differences of distance or of position which might indicate a proper motion of one or the other of these heavenly bodies.

I here terminate this brief review, in which I have been able to give only a hasty glance at the actual labors of observers upon one of the more difficult and less advanced portions of astronomical science.

P. S. M. d'Arrest announces, in No. 1378 of the "*Astronomische Nachrichten*," that he has recognized in the constellation Taurus the existence of a second nebula of variable brightness.

